3681

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TRANSMITTAL FORM

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Total Number of pages in this Submission	2+

Application Number	10/614,729
Filing Date	07/07/2003
First Named Inventor	Jonathan A. Darby
Group Art Unit	3681
Examiner Name	
Attorney Docket Number	248-00283

ENCLOSURES (check all that apply)

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment/Response
  - ☐ After final
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☐ Information Disclosure Statement/PTO-1449
- ☒ Certified Copy of Priority Document(s)
- ☐ Response to Missing Parts/ Incomplete Application
  - ☐Response to Missing Parts Under 37 1.52 or 1.53
- ☐ Assignment Papers (for an Application)
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- ☐ Licensing-related Papers
- ☐ Petition Checklist and Accompanying Petition
- ☐ To Convert a Provisional Application
- ☐ Power of Attorney, Revocation, Change of Correspondence Address
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- ☐ Status Letter
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Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Or Individual Name	JOSEPH J. JOCHMAN (Reg. No. 25,058) ANDRUS, SCEALES, STARKE & SAWALL, LLP 100 East Wisconsin Avenue, Suite 1100, Milwaukee, WI 53202
Signature	Joseph J. Jochman
Date	October 13, 2003

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Typed or printed name	Barbara A. Johnson		
Signature	Barbara A. Johnson	Date	10/13/2003

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application Of:	)
	)
JONATHAN A. DARBY ET AL	)
	)
Application No.: 10/614,729	)
	)
Filed: 07/07/2003	)
	)
Group Art Unit: 3681	)
	)
Examiner:	)
	)
NO-BACK DEVICE	)

TRANSMISSION OF PRIORITY DOCUMENT

COMMISSIONER FOR PATENTS
Washington, D.C. 20231

Sir:

Enclosed is a certified copy of the priority document identified in the formal papers of this application as filed.

The claim for priority made in the formal papers is reiterated.

Acknowledgement of the receipt of this certified copy in the next Patent Office correspondence is respectfully requested.

Respectfully submitted,

ANDRUS, SCEALES, STARKE & SAWALL, LLP

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The Patent Office
Concept House
Cardiff Road
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NP10 8QQ

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In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

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Signed Stephen Hordley

Dated 3 July 2003

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1/77

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(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

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Cardiff Road
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South Wales
NP10 8QQ

1. Your reference — R071496PGB

2. Patent application number *(The Patent Office will fill in this part)* — 0215727.9

IL02 E731646-5 D00355
'7700 0.00-0215727.9

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Lucas Industries Limited
Stratford Road, Solihull
West Midlands, B90 4LA
England

Patents ADP number *(if you know it)* 57669400 2

If the applicant is a corporate body, give the country/state of its incorporation — England

4. Title of the invention — NO-BACK DEVICE

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Marks & Clerk
Alpha Tower
Suffolk Street Queensway
Birmingham B1 1TT

Patents ADP number *(if you know it)* 18002 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	11
Claim *(s)*	CF
Abstract	
Drawing *(s)*	5 + 5

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature

Date 5 JULY 2001

12. Name and daytime telephone number of person to contact in the United Kingdom

Joanne S Pople 0121 643 5881

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NO-BACK DEVICE

The present invention relates to a no-back device suitable for use with a linear actuator, such as a ball-screw actuator or the like.

The principle of operation of so-called "no-back" devices is known in the art, for example in connection with linear actuators such as ball-screw actuators for positioning a flight control surface on an aircraft. The role of a no-back device is primarily to facilitate elimination of the effect of any forces tending to aid or oppose input torque applied to a screw of the actuator with a view to substantially preventing such forces back-driving the screw shaft.

Conventional no-back devices comprise a ratchet disk or wheel, connectable for rotation with the screw shaft of the actuator, and having a number of teeth disposed around the circumference of the disk. One or more pawl members are arranged to selectively engage with the teeth, thereby to permit the disk, and hence the screw shaft, to be rotated in a first direction but to prevent rotation of the disk in the opposite direction.

A concern with existing designs of no-back devices is that the quality of the materials used to manufacture the components of the device, in particular those used for the ratchet disk and pawl members, could potentially be defective.

Such defective materials could not usually be detected prior to installation of the device and would come to light only when the device failed, most likely

through the stripping of the teeth from the ratchet disk or the buckling of the pawl members.

Failure of this nature of the no-back device is potentially extremely dangerous since the screw shaft can then be back-driven by the aerodynamic forces acting on the flight surfaces. The flight surfaces cannot be held in position as desired and may flutter causing the aircraft to become unstable.

Owing to the demand for increased safety of aircraft and their mechanical components, there is a requirement to build redundancy features into such actuators and no-back devices to reduce the likelihood and effect of their failure.

According to one aspect of the invention, therefore, there is provided a no-back device comprising first and second ratchet members connectable to a rotating member for rotation therewith and at least one pawl member, engagable with at least one of said ratchet means, wherein said first and said second ratchet means are formed from respective materials having different chemical and/or physical properties.

By employing two ratchet members which are made of different materials or similar materials which have been subjected to different treatment processes, the likelihood of both disks suffering a latent failure are considerably reduced.

Preferably, the first and second ratchet members are arranged for rotation in the same direction. Advantageously, the at least one pawl member is

arranged to permit rotation of the first and second ratchet members in one direction but to substantially prevent rotation of at least one of the ratchet members in the opposite direction.

Conveniently, the first and second ratchet members are joined or connected together to substantially prevent relative rotation therebetween.

Advantageously, the first and second ratchet members have respective interlocking means for interlocking said ratchet members together, thereby to prevent said relative rotation. Preferably, one of said ratchet members is provided with one or more projections on a surface thereof while the other ratchet member is provided with one or more corresponding indentations for engagement with said one or more projections.

The projections and indentations serve to interlock the first and second ratchet members together to substantially prevent relative rotation therebetween. Moreover, by providing one of the ratchet members with one or more projections and the other ratchet member with one or more corresponding indentations, it is possible to ensure that two like disks are not capable of being used together. This further improves reliability.

Preferably, the no-back device includes two pawl members, each being engagable with at least one of the ratchet members. Conveniently, a first one of said pawl members is formed from a first material while a second one of said pawls is formed from a second material having different physical and/or chemical properties from the first material.

Preferably, said pawl members are mounted to a fixed part of the no-back device by means of a spindle or the like. More preferably, the spindle of one pawl member is a different size or shape from that of the other pawl member.

Advantageously, the different mounting arrangements for the pawl members ensure that two like pawls cannot be used together.

Advantageously, the first ratchet member is angularly offset from the second ratchet member. Conveniently, the offset angle is approximately 1°. This ensures that, during normal operation, the or each pawl member is engagable with only one of said ratchet members. Should the ratchet member suffer wear or breakage, the or each pawl member will become engagable with the second ratchet member which has suffered no wear or breakage.

The present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a preferred form of no-back device according to the invention,

Figure 2 is a section through a ball-screw actuator incorporating the no-back device of Figure 1,

Figure 3 is an enlarged view of part of the actuator of Figure 2,

Figure 4 is a transverse section through the actuator of Figure 2,

Figure 5 is a section along the line F-F in Figure 4, and

Figure 6 is a section along the line G-G in Figure 4.

Referring to Figure 1, a preferred form of no-back device according to the invention is shown generally at 10. The no-back device 10 comprises first and second ratchet members in the form of annular disks or wheels 12, 14. Each ratchet member 12, 14 has a plurality of circumferential teeth 16, each tooth having a leading facet 16a, extending generally tangential to the local circumference of the wheel, and a radially-directed trailing facet 16b.

The first and second ratchet members 12, 14 are fixedly joined together such that relative rotation therebetween is hindered or substantially prevented. In one embodiment, the first and second ratchet members 12, 14 are adhered together using a suitable adhesive but may additionally or alternatively be connected together by mechanical means such as rivets, bolts or the like.

In a preferred embodiment, shown in Figure 1, the second ratchet member 14 is provided on one surface thereof with an upstanding projection 18 which is arranged, in use, to engage in a corresponding indentation 20 formed in the opposing surface of the first ratchet member 12. A plurality of such indentations/projections may be formed on the abutting faces of the first and second ratchet members 12, 14 respectively. Advantageously, however, only the first ratchet member 12 is provided with the indentations whilst only the second ratchet member 14 is provided with the projections. The advantages of this are explained below.

It will be understood from the foregoing description and the drawings that the teeth on the first and second ratchet members are unidirectional, i.e. they are oriented in the same direction for rotation of the first and second ratchet members in one direction only. The no-back device includes first and second pawl members 22, 24 pivotally mounted by means of respective spindles 32, 34 to mounting points 26, 28 connected to a fixed part of the no-back device 10. The pawl members 22, 24 are arranged to engage with the circumferential teeth 16 of the first and second ratchet members 12, 14 in the manner of conventional ratchet and pawl mechanisms.

Specifically, the first and second pawl members 22, 24 are arranged to permit rotation of the first and second ratchet members 12, 14 in one direction but to substantially prevent rotation in the opposite direction. Rotation of the first and second ratchet members 12, 14 in the first direction is permitted by virtue of pivotal movement of the pawl members causing them to ride over the circumferential teeth 16. Rotational movement of the first and second ratchet members 12, 14 in the opposite direction causes the pawl members 22, 24 to engage with and abut the trailing facet 16b of respective teeth 16.

Importantly, the first and second ratchet members 12, 14 are formed from materials having different chemical, mechanical and/or physical properties. For example, the first ratchet member 12 may be formed from steel which is AMS 6260 Carburized whilst the second ratchet member 14 may be formed from steel which is S82 Carburized.

The use of different materials for each of the ratchet members 12, 14, or similar materials having different properties, or materials which have been subjected to different treatment processes, ensures that any manufacturing problems affecting one of the ratchet members, which may make it insufficiently hard or susceptible to wear or fatigue, are highly unlikely to be experienced by the other ratchet member. Thus, for example, if during manufacture of the ratchet members, a first batch is produced with a mechanical fault or other material defect, the assembled no-back device is extremely unlikely to fail since the other ratchet member will not come from the same batch. Furthermore, the provision of the indentations 20 on the first ratchet member 12 and the corresponding projections 18 on the second ratchet member 14 ensure that two like ratchet members cannot be assembled together to form the no-back device.

In addition, the pawl members 22, 24 may also be formed from materials having different chemical, mechanical and/or physical properties as with the ratchet members 12, 14. For example, the first pawl member 22 may be formed from steel which is AMS 6260 Carburized while the second pawl member 24 may be formed from steel which is S82 Carburized. Again, the use of pawl members being formed from different materials, or from similar materials having different properties or having been subjected to different treatment processes, ensures that the likelihood of failure of both pawl members 22, 24 owing to defective materials or manufacturing processes is minimised.

To ensure that the use of two like pawls in the no-back device is not possible, the spindle 32 on which the first pawl 22 is mounted is a different size and/or

shape to the spindle 34 on which the second pawl member 24 is mounted. This is more clearly shown in Figures 5 and 6. Thus, the first pawl member 22 cannot be accidentally mounted to the second mounting point 28 whilst the second pawl member 24 cannot be mounted to the first mounting point 26.

As illustrated in Figure 1, the first and second ratchet members 12, 14 are joined together such that they are angularly offset by a relatively small amount. The amount of offset can be selected as desired but is preferably less than 5° and more preferably approximately 1°. In particular, the amount of angular offset of the first and second ratchet members 12, 14 must not be great enough to cause the pawl members to wear out the teeth of the lagging ratchet member.

The provision of angularly offset ratchet members 12, 14 ensures that, during normal operation, only the lagging ratchet member, namely the second ratchet member 14 in Figure 1, is engaged by the pawl members 22, 24. Since the first ratchet member 12 which angularly leads the second ratchet member 14 is not engaged by the pawl members 22, 24, it is therefore maintained in a full, unworn working condition. Should the second ratchet member 14 fail or wear through prolonged use then the unworn first ratchet member 12 will ensure that the no-back device does not fail completely.

As best illustrated in Figure 1, the pawl members 22, 24 are asymmetrical about their longitudinal axis, having a generally L-shaped form. Specifically, each pawl 22, 24 has an engaging portion 22a which engages the teeth 16 of the first and second ratchet members 12, 14. The engaging portion 22a is of greater width than a mounting portion 22b of the pawl member through

which the spindle 32 passes. The pawl member 22 is mounted such that the region of the engaging portion 22a of the pawl member 22 which engages with the teeth of the second ratchet member 14 is substantially axially aligned with the mounting portion 22b of the pawl member 22. This is to ensure that the load path through the pawl member 22, in use, is directed substantially through the full length of the pawl member to minimise the likelihood of fatigue.

The region of the engaging portion 22a of the pawl member 22 which is arranged for engagement with the teeth of the first ratchet member 12 is axially offset from the mounting portion 22b of the pawl member 22. This is not considered disadvantageous since the first ratchet member 12 is effectively a back-up mechanism for the second ratchet member 14. Moreover, the L-shaped pawl member 22 reduces weight compared with a pawl member having a constant thickness. The other pawl member 24 is similarly shaped and arranged.

Referring to Figures 2 to 4, these illustrate sections through a ball-screw actuator 100 incorporating the no-back device of the invention. The first and second ratchet members 12, 14 are selectively engagable with a rotating shaft or ballnut 102 of the ball-screw actuator for rotation therewith by means of a thrust bearing 104 disposed on one side thereof and a friction disk 106 disposed on the other side thereof and fixedly connected to the ballnut 102.

In use, rotation of the ballnut 102 causes a linear movement of an actuating arm 108 in one direction, whilst rotation of the ballnut 102 in the opposite direction causes linear movement of the actuating arm in the other direction.

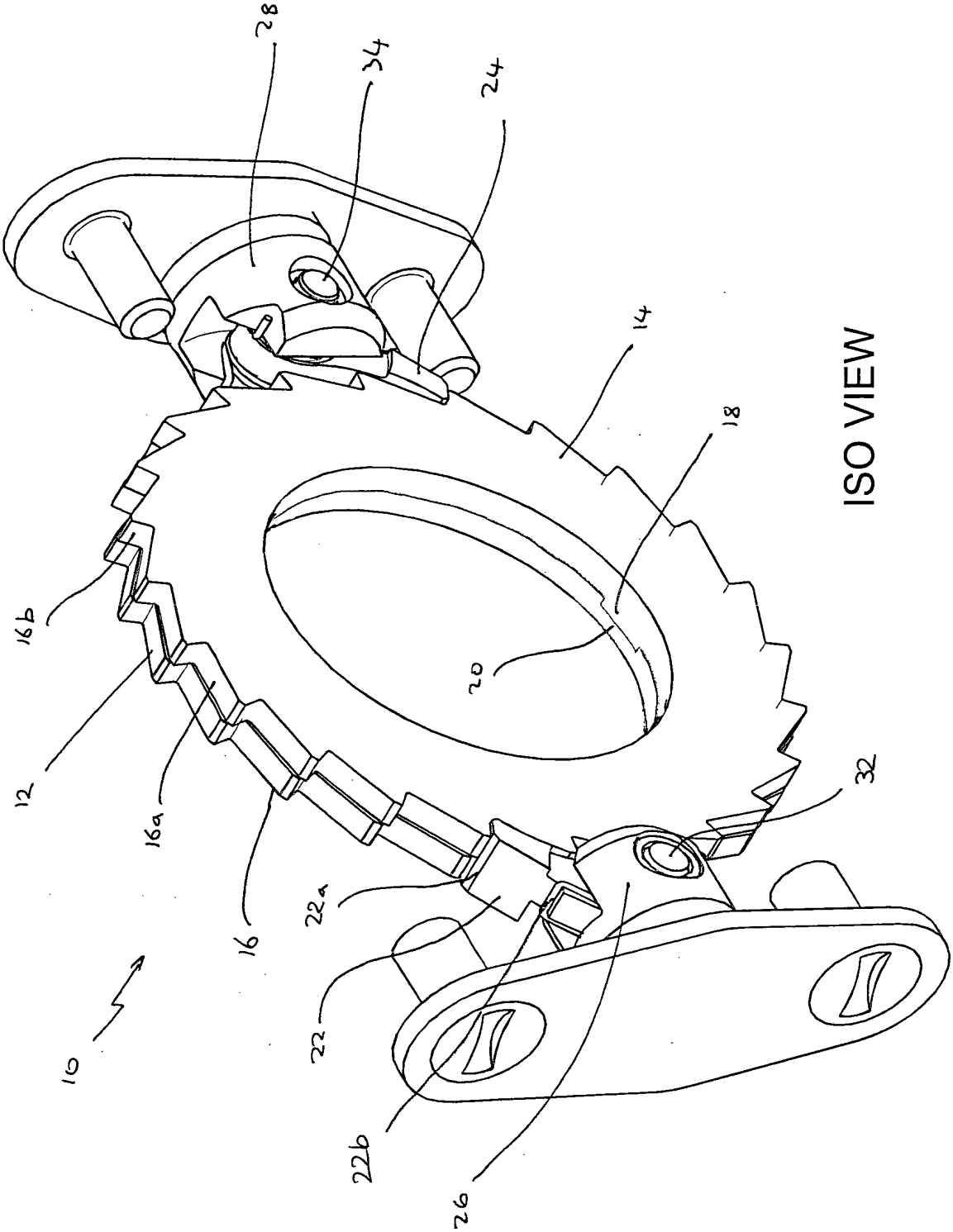
In normal operation, when the ballnut 102 is rotated to actuate the arm 108 in a first direction, the ratchet members 12, 14 are free to rotate with the ballnut 102, together with the thrust bearing 104 and the friction disk 106. Under such circumstances the pawl members 22, 24 engage with the teeth of the ratchet members 22, 24 in such a way as to permit the ratchet members 22, 24 to ride over the pawl members 22, 24 and the actuating arm 108 is urged to the right in Figure 3.

In circumstances in which the ballnut 102 is driven in the opposite direction, (i.e. to move the actuating arm 108 to the left), the ratchet members 22, 24 lock against the pawls. Bearings 110 mounted on the ballnut 102 permit relative movement between the arrangement of the ballnut 102, the thrust bearing 104 and the friction disk 106, and the locked ratchet members 22, 24.

If a compressive load is applied to the actuating arm, for example due to external aerodynamic forces, the thrust bearing 104 is compressed against the ratchet wheel 12 and a frictional force locks parts 104, 12, 14, 110 and 106 together. As the ratchet members 12, 14 lock against the pawl members under the compressive load, back loading of the actuator is therefore prevented.

It will be understood that the number of pawl members can be selected as desired. Also, the choice of materials for the ratchet members and the pawl members can be selected as desired but, importantly, they should be formed from materials having different properties.

It will be understood by those skilled in the art that the no-back device of the present invention provides a simple and effective improvement to the reliability of existing no-back devices which entails minimum weight increase and improved ease of manufacturing.



ISO VIEW

FIGURE 1

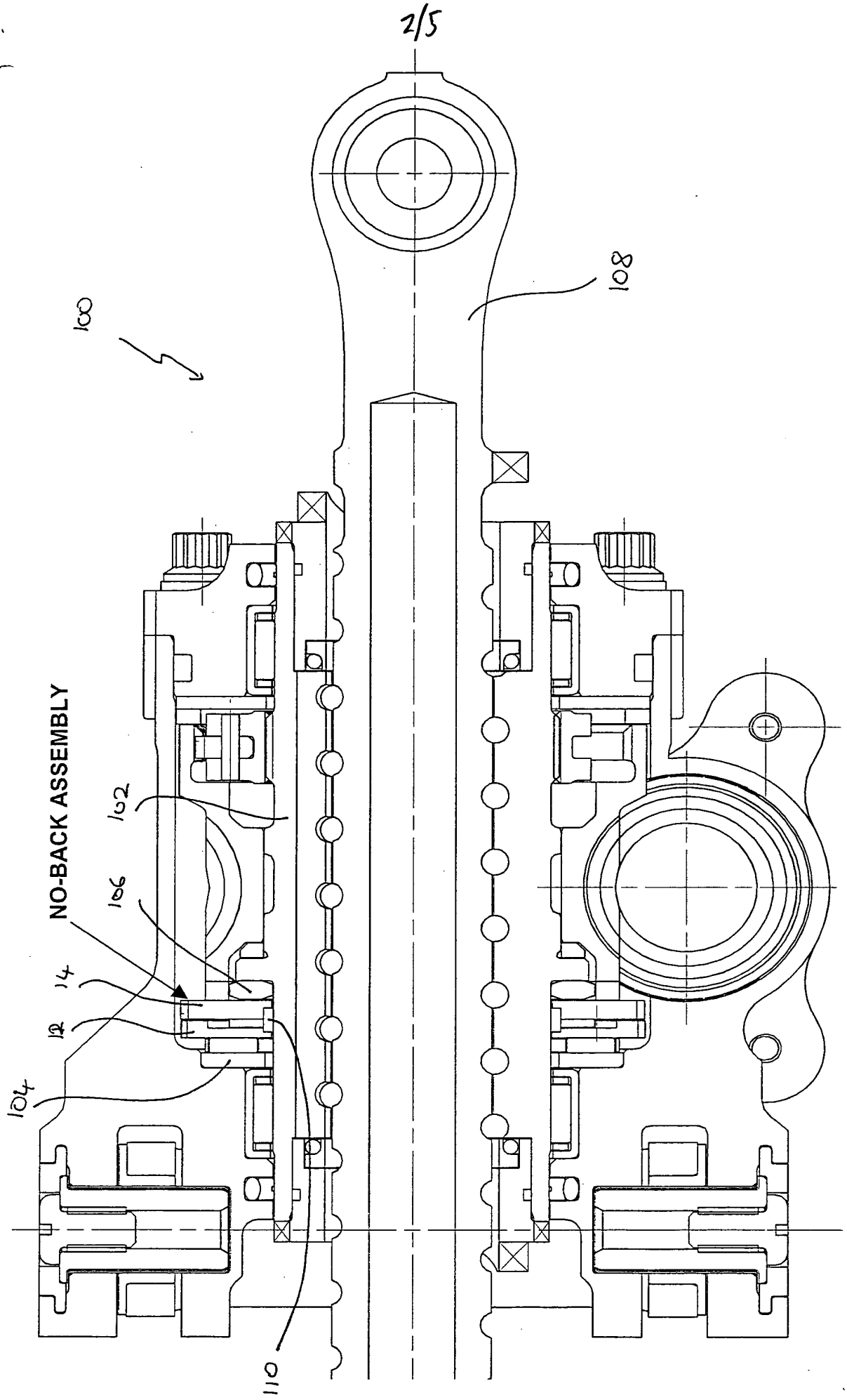

SECTION THRO' BALLSCREW ACTUATOR
NO-BACK ASSEMBLY
100
102
104
106
108
110
12
14

FIGURE 2

SECTION THRO' NO-BACK ASSEMBLY

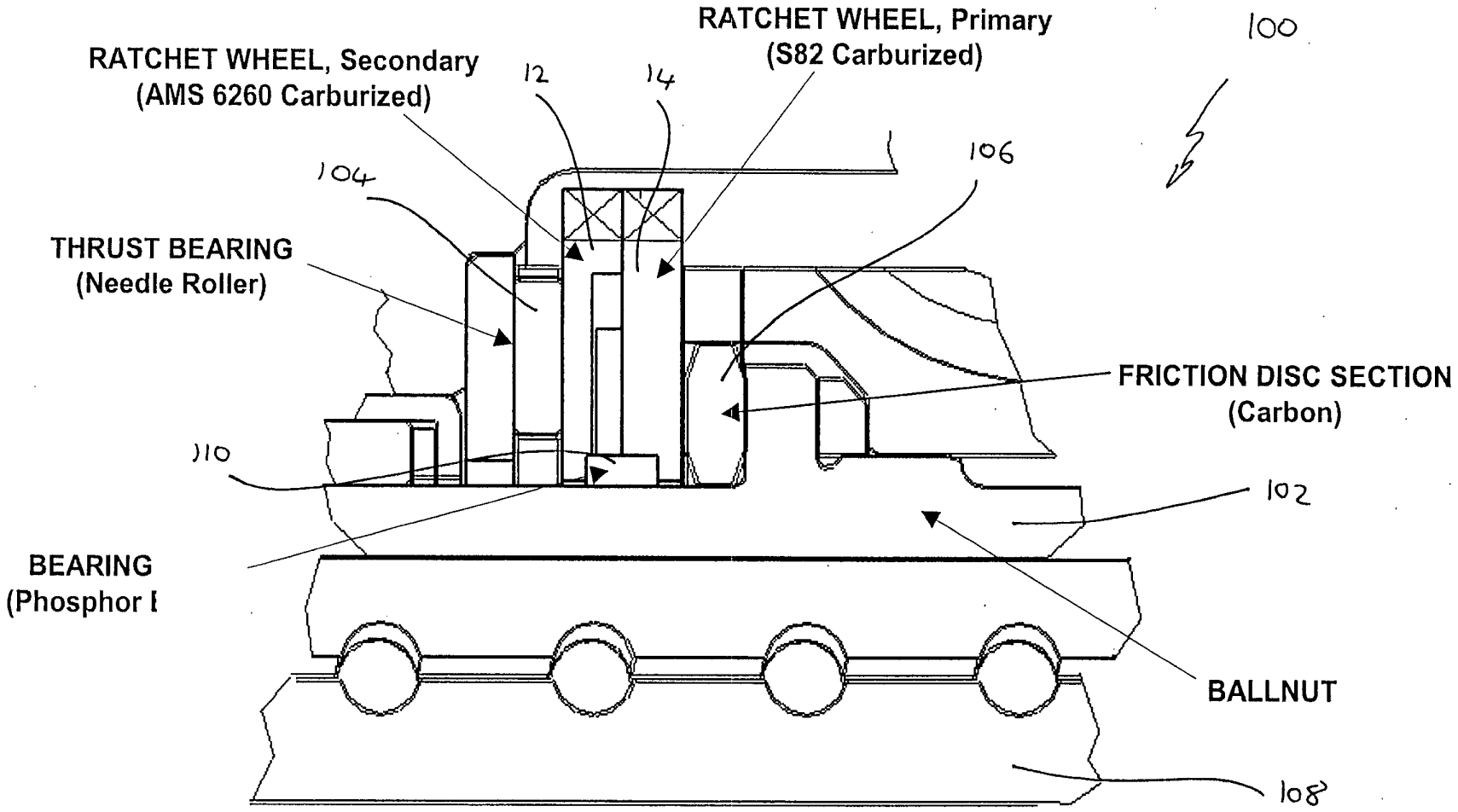
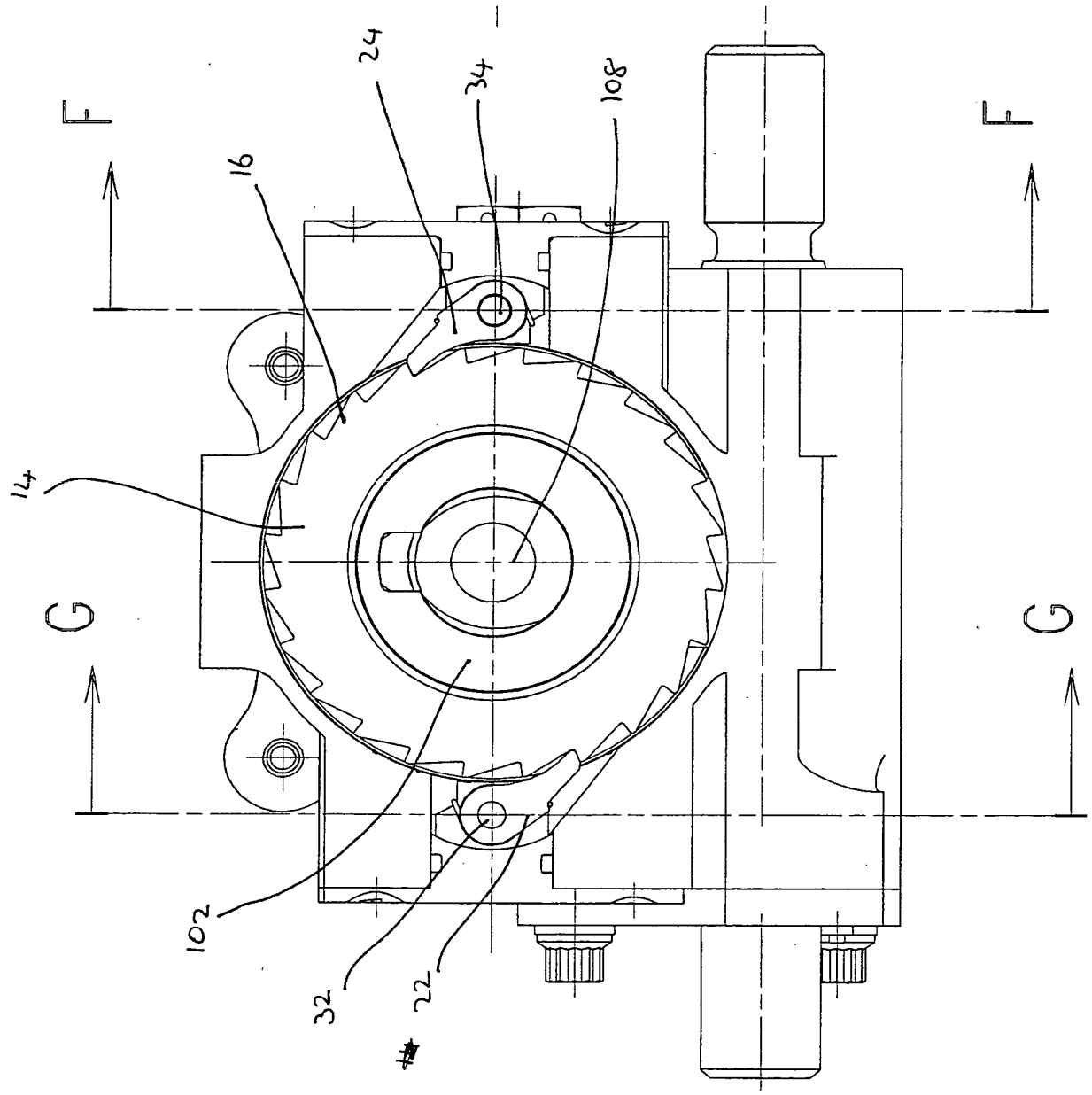
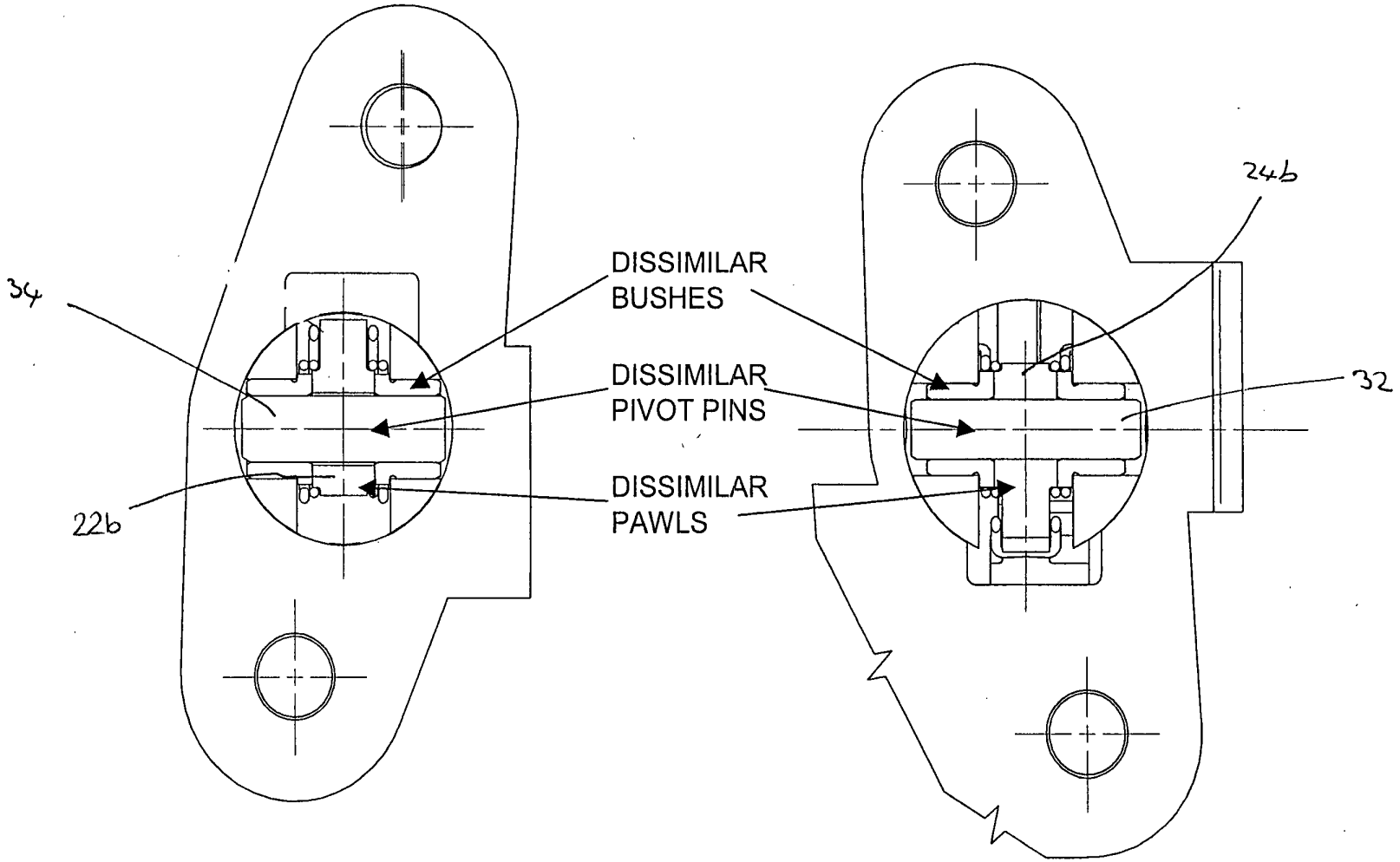


Figure 3



SECTION THRO' NO-BACK

FIGURE 4



SECTION F/F

SECTION G/G

FIGURE 5

FIGURE 6